Long-term silica flux and soil development in the H.J. Andrews Forest

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Introduction

- Soil development is a complex process with many different environmental factors influencing the evolution of soils and the ecosystems they sustain.
- Factors like aspect, slope position, parent material, and elevation each have different effects on the rate and extent of chemical and mineral dissolution, and as the composition of a soil changes so too does the ecology of the surrounding area.
- At a much smaller scale, the presence and form of elements like silica, iron, aluminum, and manganese can provide background as for how the soil has been altered by the environmental conditions. Silica in particular can be used in understanding a soil's parent material, and there is further investigation to see how silica contributes to plant structure and even indirectly affecting climate control.
- In order to observe the long-term developments and trends in a complex system we needed reliable data from several relatively close sources. The H.J. Andrews Experimental Forest is a long-term ecological research (LTER) site, and has been monitoring silica flux since as far back as 1969.
- Another benefit to the H.J. Andrews is that for most experimental watersheds (WS) in which there has been clear-cut logging there is an unlogged watershed to function as a control. This way we can also see the impact of human presence between watersheds.

Objectives

This is an exploratory study with the general purpose of better understanding the geochemical and morphological changes in soil across a landscape.

Looking SW in to the HJA from Carpenter Mt. fire lookout

Other secondary objectives are that we hope to:

- Identify any existing links between variables like parent material, aspect, slope, and elevation and the degree of soil genesis.
- Observe the long-term translocation of silica across individual watersheds and also across the forest as a whole.
- Identify the form and abundance of iron oxides throughout the forest using oxalate and dithionite-citrate extractions.
- Use lab interpreted data from field samples to support existing soil development theories.

Study Site

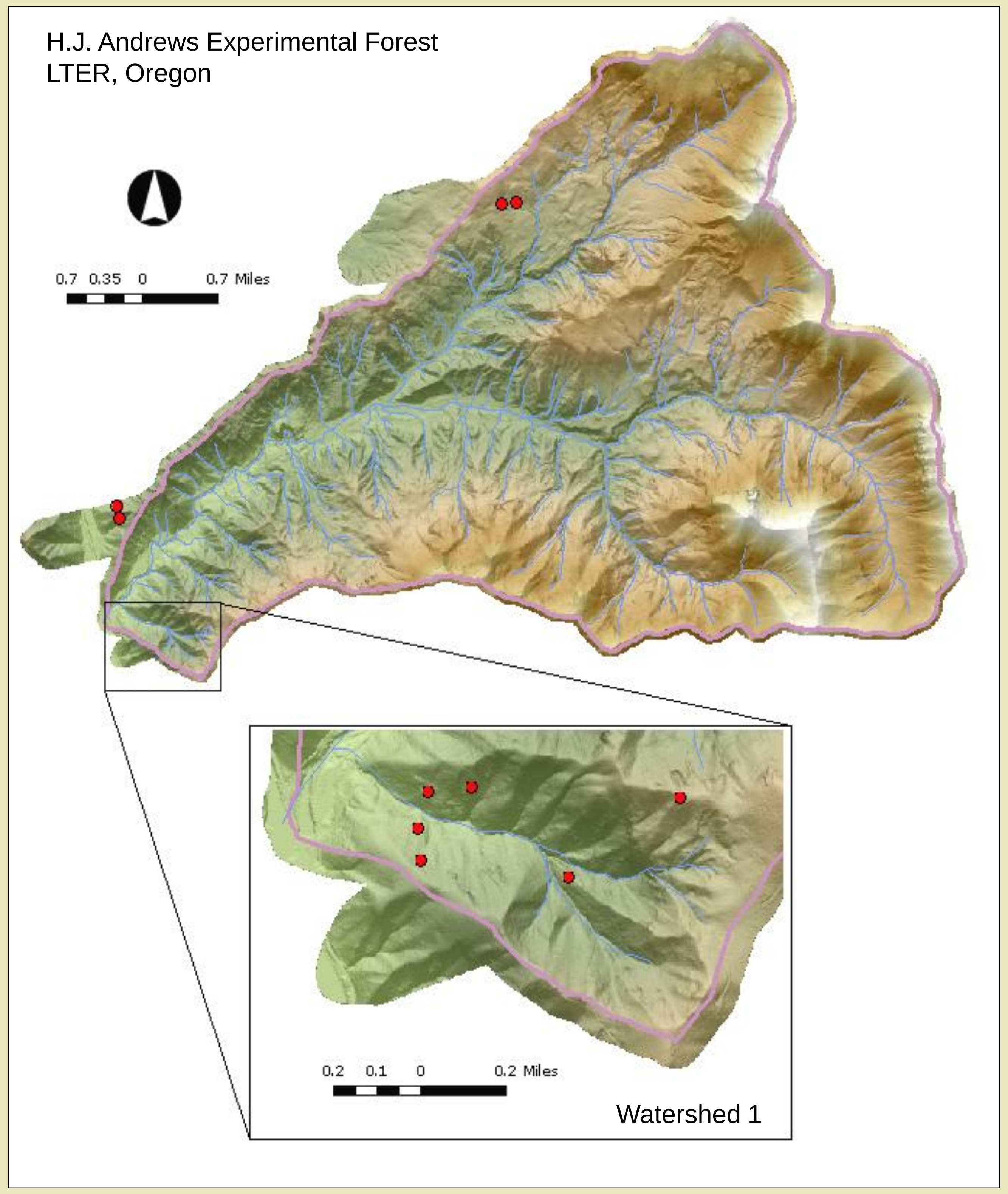


Fig. 1 Pit 4, WS 1

- Ten pits were dug throughout the HJA. The locations were chosen based on variables including elevation, parent material, aspect, and slope position.
- Figures 1 & 2 are photos of two soil pits within watershed 1. The main variable between these two pits is their aspects; pit 4 is on a South-facing slope but pit 6 is on a North-facing slope. The hydrologic conditions and vegetation were very different between the two due to the difference in sun exposure.
- Figures 3 & 4 are of two pits along the crests of watersheds 1 and 6. Both being clear cut, their variables are elevation and weather conditions. Pit 5 had deep clay formation while pit 7 was less developed possibly due to snow pack.

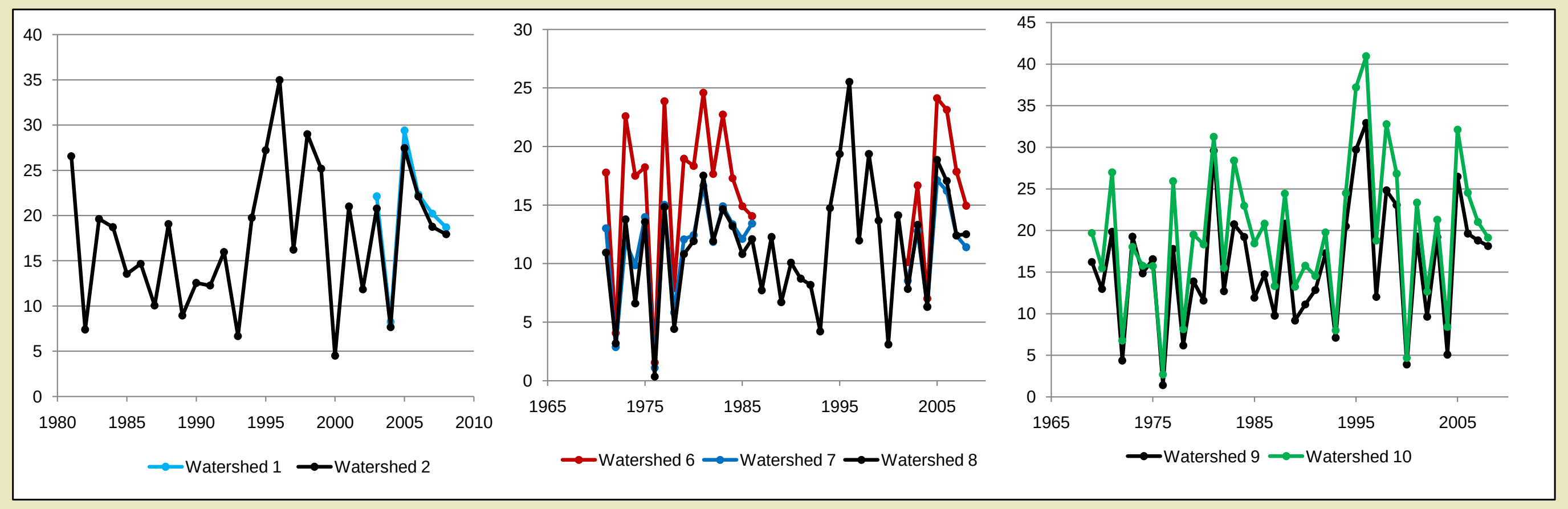
Fig. 3 Pit 7, WS 6

Fig. 2 Pit 6, WS 1

Fig. 4 Pit 5, WS 1

Results

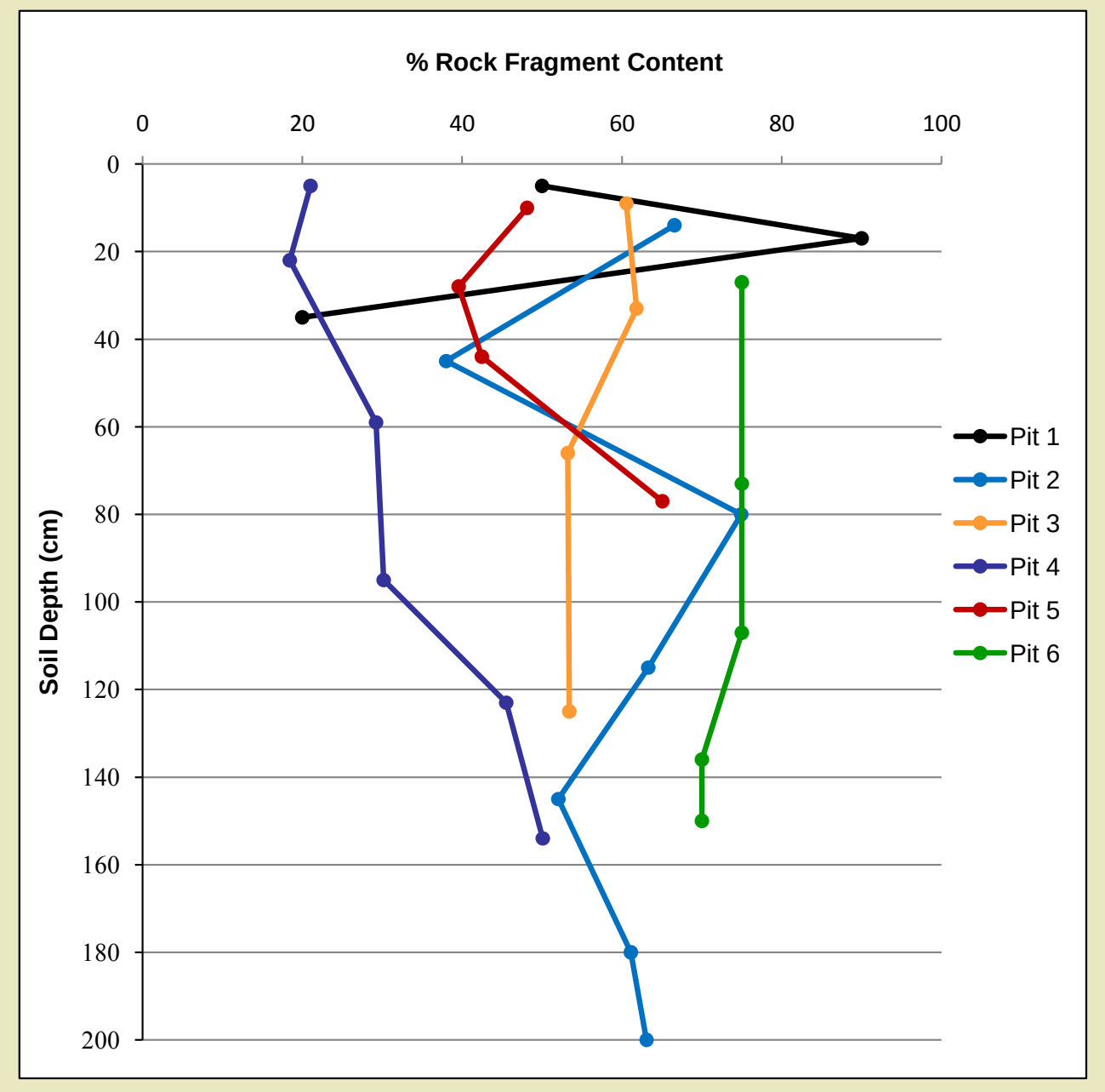
Annual Silica Export in Kilograms per Hectare Between Experimental and Control Watersheds



Soil Forming Factors

Pit	Water shed	Slope position	Aspect	Elevation (ft)	Parent Material	Vegetation Type
1	1	Back slope	North	2300	Basalt	Doug fir & Hemlock
2	1	Back slope	North	1900	Red tuff & breccia	Doug fir & Hemlock
3	1	Back slope	South	2100	Red tuff & breccia	Doug fir & Hemlock
4	1	Back slope	South	1900	Basalt	Doug fir & Hemlock
5	1	Ridge top	-	3000	Unknown	Doug fir & Hemlock
6	1	Back slope	North	2000	Green tuff & breccia	Doug fir & Hemlock
7	6	Ridge top	-	3200	Andesite	Doug fir & Hemlock
8	6	Back slope	South/ SE	3200	Andesite	Doug fir & Hemlock
9	10	Back slope	South/ SE	1750	Andesitic tuff & breccia	Doug fir & Hemlock
10	10	Back slope	South/ SE	1850	Andesitic tuff & breccia	Doug fir & Hemlock

Differences in WS 1 soil development



Soil Physical and Chemical Properties

Pit	Horizon Depth (cm)	Horiz. desig.	Texture	% Rock Fragment	pH in H_2O	Al_d (mg/g)	Fe_d (mg/g)	Si_d (mg/g)	Al_O (mg/g)	Fe_O (mg/g)	Si_O (mg/g)	Fe_O/Fe_D
1	28-43	3B		20*	6.44	9.06	23.06	5.62	11.21	4.51	6.16	0.20
2	0-28	A	Sandy loam	67	6.43	6.15	21.46	4.68	5.30	3.05	0.09	0.14
	28-65	B/A	Sandy loam	38	6.53	3.68	19.86	3.83	3.94	2.32	-	0.12
	65-100	BA	Loamy sand	75	6.13	3.45	20.65	4.17	3.29	1.89	-	0.09
	100-129	B	Silt loam	63	6.33	3.24	18.68	4.72	2.96	1.89	-	0.10
	129-164	C/B	Loam	52	5.46	3.66	22.29	5.04	3.13	1.96	-	0.09
	164-199	B	Silt loam (clay rich)	61	5.41	3.91	18.97	9.17	3.34	1.73	-	0.09
	>199	CB		63	6.30	3.57	16.40	8.53	3.67	1.98	0.07	0.12
3	0-17	A	Clay loam	61	6.35	5.72	21.31	5.94	5.92	2.57	0.92	0.12
	17-48	B	Silty clay loam	62	6.39	-0.10	-1.50	0.18	5.55	2.33	0.40	-1.55
	48-101	2AB	Loam	53	6.37	5.58	17.77	6.29	5.79	2.30	0.34	0.13
	101-148	2BA	Clay loam	53	5.86	6.54	33.24	4.46	5.96	2.05	0.40	0.06
4	0-9	A	Clay loam	21	6.38	6.21	26.16	5.34	6.27	4.64	0.67	0.18
	9-35	AB	Clay loam	18	6.59	4.50	23.31	4.81	5.19	3.93	0.29	0.17
	35-82	BA	Clay loam	29	6.54	4.37	22.07	4.76	5.49	3.87	0.38	0.18
	82-107	2B/A	Clay loam	30	6.38	3.14	12.35	2.49	5.61	3.79	0.90	0.31
	107-140	2B	Silty clay	46	6.54	4.80	21.93	11.44	4.31	2.64	0.54	0.12
	140-168	2BC	Silty clay	50	6.32	4.17	18.31	11.19	4.23	2.78	0.52	0.15
5	0-21		Sandy loam	48	6.05	7.04	10.04	5.72	7.76	5.28	0.09	0.53
	21-36		Sandy loam (clay rich)	40	6.03	5.27	9.08	4.77	8.35	6.14	0.16	0.68
	36-52		Sandy loam	42	5.67	5.32	11.49	6.68	6.92	4.77	-	0.42
	52-103		Clay loam	65	5.49	7.21	12.99	8.47	-0.27	-0.37	-	-0.03
6	0-54	A1	Silt loam (clay poor)	75*	6.29	5.09	10.68	2.85	4.94	3.99	-	0.37
	54-92	A2	Silt loam (clay poor)	75*	6.33	4.35	12.34	3.33	4.15	3.90	0.03	0.32
	92-123	A3	Silt loam (clay poor)	75*	6.40	5.80	12.53	3.17	6.24	4.22	0.56	0.34
	123-149	Bw1	Clay loam	70*	6.35	10.83	28.09	8.14	6.40	3.88	0.98	0.14
7	0-4	A	Sandy loam (clay poor)	30*	5.50	8.51	7.38	4.30	10.61	4.20	2.23	0.57
	4-13	E	Sandy loam (clay poor)	45*	5.78	10.32	11.12	5.25	13.92	4.78	4.37	0.43
	13-33	BC	Sandy loam (clay rich)	50*	6.07	10.84	17.33	7.03	12.53	3.25	4.21	0.19
	33-55	C	Loamy sand	75*	5.95	10.84	18.18	5.97	13.52	2.57	4.99	0.14
8	0-13	A	Sandy loam (clay poor)	59	5.77	10.01	7.88	5.32	18.95	5.13	10.24	0.65
	13-53		Sandy loam (clay poor)	53	5.92	8.71	8.53	5.15	16.89	4.44	10.46	0.52
	53-75		Sandy loam (clay poor)	49	5.93	8.54	11.38	5.16	16.09	3.51	10.52	0.31
	75-107	BC	Sandy loam (clay rich)	48	5.87	7.50	17.97	4.38	10.15	1.75	5.50	0.10
	107-139	C/B	Sandy loam (clay rich)	55	5.74	10.24	29.38	7.36	10.01	2.42	3.46	0.08
	>139	C	Sandy loam (clay rich)	45	5.73	6.85	32.85	7.19	6.48	2.41	0.86	0.07
9	0-22	A	Clay loam	50	5.94	4.52	25.75	3.14	4.42	2.43	0.00	0.09
	22-60	A/C	Clay loam	53	5.92	5.14	17.02	3.03	5.32	2.15	0.56	0.13
	60-92	AC	Sandy loam	35	5.91	3.48	13.73	2.90	3.62	1.35	-	0.10
	92-120	2AE	Clay loam	57	5.78	3.83	23.38	5.63	3.20	0.75	-	0.03
	120-150	2EB	Clay loam	56	5.67	3.43	9.01	3.68	3.05	0.36	-	0.04
10	0-29	AC	Silt loam (clay poor)	67	6.13	6.16	21.96	4.90	6.37	4.16	0.43	0.19
	29-49	BC	Silt loam (clay rich)	45*	6.01	5.87	29.18	5.47	4.01	2.09	-	0.07
	49-77	2BC	Sandy clay	70*	6.25	4.76	28.85	5.22	3.53	1.62	0.06	0.06

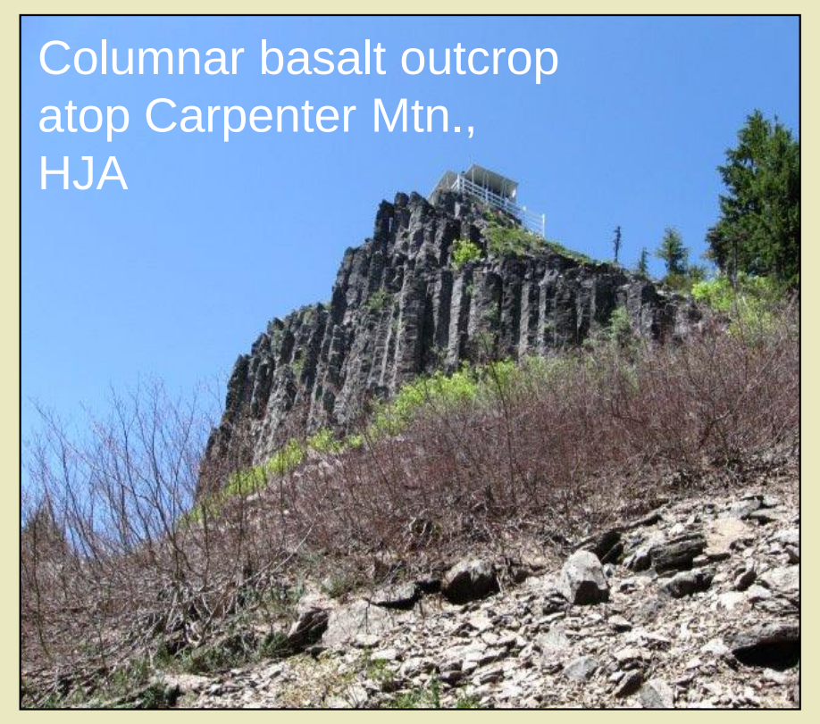
**Field estimate*

Summary & Conclusions

- While there are distinct differences in silica export between experimental and control watersheds, it is unclear what specific factors control the change between the two. Also, the silica flux in the "high elevation" watersheds (6, 7, & 8) are greater than those of watersheds 1, 2, 9, & 10 which are up to 1,500 feet lower. Silica flux appears to be directly influenced by the elevation.
- There was a huge variability in rock fragment content with depth within any given soil. Even looking across a small spatial area there were few similarities in developmental stage or total depth. Landslides seemed a reasonable explanation due to the steep valley walls.

High clay soils in Pit 4, Watershed 1

- The oxalate-extractable silica is very low in many of our pits, except the two in watershed 6 (pits 7 & 8). This may be a function of elevation (and the resulting climate differences) or of the andesitic parent material.
- The ratios of oxalate-extractable iron to dithionite-citrate-extractable iron (Fe_O/Fe_D) are relatively low, which implies that there are more crystalline iron oxides like goethite as opposed to less crystalline oxides like ferrihydrite.
- Many of the slopes throughout the H.J. Andrews were quite steep (upwards of and therefore likely to experience frequent landslides. Several of our soil pits showed evidence for multiple landslides in terms of discontinuities in clay or rock fragment content with depth.



Columnar basalt outcrop atop Carpenter Mtn., HJA

Julie, Markus, and Nick on the steep slopes of WS 1

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